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EVALUATION OF COMPOSITE LAMINATED BY STACKING SEQUENCE WITH TIO2-AL2O3 NANOCOMPOSITE

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ABSTRACT

This paper investigates the effect of titanium oxide and aluminium oxide on Kevlar fiber. The TiO_2 and Al_2O_3 are mixed with epoxy at the ratio of 1:2 and they are applied on the lamina to fabricate the laminate by vacuum bag moulding process. The laminate is made by the stacking sequence technique of orientation of 0/60/45/45/60/0. The laminate consisted of six layers of Kevlar fiber. Four types of specimen configurations are fabricated and tested for mechanical properties. The nano composites are mixed by sonication process. The results reveal that, the fiber with ratio of one part of TiO_2 and two parts of the Al_2O_3 yields high strength than the other types of specimen. In addition, the results are validated computationally using a numerical method by applying Johnson cooks damage theory

KEYWORDS: Nano composite, Kevlar, Epoxy, Sonication & Titanium oxide

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Original Article

INTRODUCTION

Composite materials gaining their importance due to its unique strength compared to metals [1-10]. These days, composite materials are replacing the metals very effectively with better strength to weight ratio. The stiffness of the structures is increased widely [2, 3, 4, 5, 6, 9, 10]. Engineering research has focused to develop newer and better materials to use for wide applications [7, 8, 12, 14, 16]. However the damage to the materials by the atmosphere is the big worry for several centuries. We have two important phases in the fabrication of laminate reinforcement and matrix. These two important phases increase the strength of the material to carry high intensity loads. Reinforcement phase helps fiber to take huge loads and the matrix phase helps to distribute loads evenly throughout the lamina. Kevlar has a huge application in pharmacy sectors and mechanical industries [2, 3, 4, 5, 6, 9, 10, 11, 13, 15].

EXPERIMENTAL SETUP

Kevlar fiber is taken as the specimen for its high stiffness to weight ratio. Application of Kevlar is very high compared to other fiber in defence areas due to his ballistic strength. Kevlar is used to make bullet proof vests and impact resistance sheet. This paper presents the evolution of Kevlar fiber when they treated with nano composite to produce high strength material. We have taken two types of nano composite for this study titanium oxide and aluminium oxide. These two types of nano composite are mixed with each other by a manual stirring process. The fiber is sliced 30*30cm sheet. The six layers of the Kevlar are taken of dimension 30*30 cm of orientation of 0 deg, 45 deg, and 90 deg. These six layers of Kevlar are reinforced with the nano composite by vacuum bag process. The fibers are arranged at the orientation of 0/60/45/45/60/0 degree. The fibers are reinforced with epoxy resin and nano composite. The epoxy resin and nano composite are taken at the ratio of 2:1.

Nanocomposite is mixed with the resin by sonication technique. The mixed nano composite – epoxy paste is applied over the lamina to make a structure. The structure allowed to cure up to 24 hours. The process of reinforcement has been done without adding the hardener on the resin since the nano composite it acts like a catalyst. The above four types of specimens are fabricated in the vacuum bag process and tested for mechanical properties [1, 17, 18, 20, 21]. The Specimens are made of different orientation of 0, 45, 60 and 90. Four types of configuration are fabricated based on the percentage of titanium oxide and aluminum oxide. The specimen A made of Kevlar 149 without nano composites, B is made of 30g of titanium oxide, C is made of 30g of aluminium oxide and D is made of 15g of titanium oxide, 15g of aluminium oxide respectively. Above all configurations are tested for mechanical properties and compared with each other.

Table 1: Specimen Details

Contents	Fiber	Fiber orientation	TiO_2	Al_2O_3
A	Kevlar-149	0/60/45/45/60/0	0	0
B	Kevlar-149	0/60/45/45/60/0	15g	0
C	Kevlar-149	0/60/45/45/60/0	0	15g
D	Kevlar-149	0/60/45/45/60/0	15g	15g

RESULTS AND DISCUSSIONS

The specimens are tested for the mechanical properties under tensile and compression load. The specimen results are tabulated in table 2 and 3. The graphical plots are represented for various properties from figure 1 to figure 7.

The table 2 presents the mechanical properties of all specimens under tensile load. The test is carried on the Universal testing machine, Sathyabama University, Chennai. The values are computed and plotted to represent them graphically for better understanding of readers from figure 1 to figure 7. The table 3 presents the properties of fiber under compression load. Figure 1 provides the comparative plot of all types of configurations, from the curve it is evident that fiber with titanium oxide and aluminium oxide has high strength compared to other configurations. The figure 2 provides the bar chart of all specimens, which shows K- TiO2- Al_2O_3 showing superior strength compared to other fibers.

Table 2: Tensile Property of Al-Kevlar Nano Composite

Contents	Kevlar-149	K149-Al	K149- TiO_2	K149-Al/ TiO_2
Ultimate/ Break Load (KN)	12.0	16.5	19.2	20.2
Disp at Fmax(mm)	26.0	27.0	27.5	27.0
Ult.Stress(Mpa)	325.0	369.0	380.0	385.0
Yield stress (Mpa)	195.0	341.0	365.0	375.0
YS/UTS Ratio	0.7	1.5	1.6	1.9
Elongation	18.9	42.0	38.0	45.0

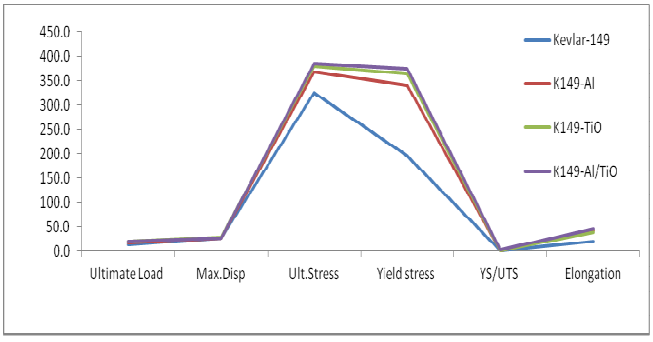

Figure 1: Comparative Plot for all Configurations

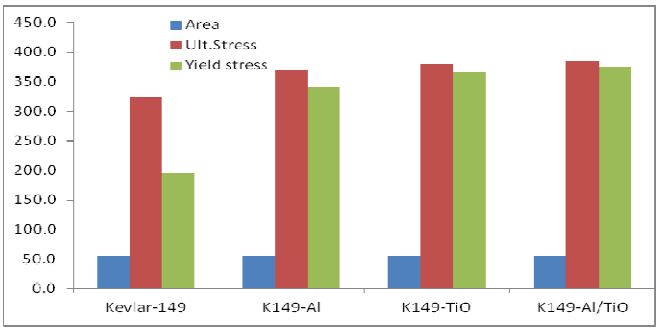

Figure 2: Graphical Plot for Specimen A/B/C/D(Tensile)

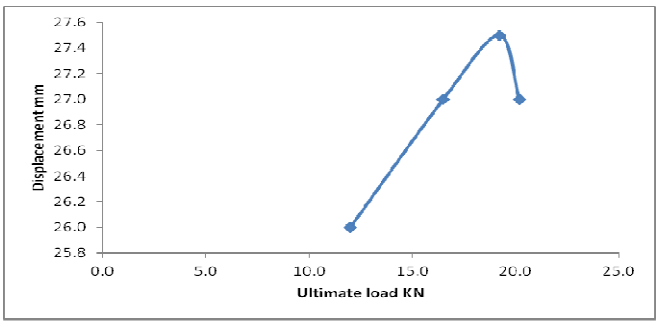

Figure 3: Ultimate Load to Strain Plot at Tensile Load

Table 3: Tensile Property of Al-Kevlar Nano Composite

Contents	Kevlar-149	K149- Al_2O_3	K149- TiO_2	K149- Al_2O_3 / TiO_2
Ultimate/ Break Load (KN)	0.5	0.6	0.8	0.9
Disp at Fmax(mm)	3.1	5.9	6.3	7.5
Max.Displacement	4.5	9.3	12.1	13.2
Ultimate stress	81.3	90.5	120.0	133.0

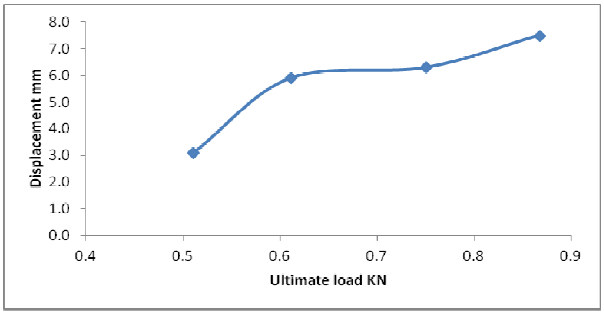

Figure 4: Ultimate Load to Strain Plot at Compressive Load

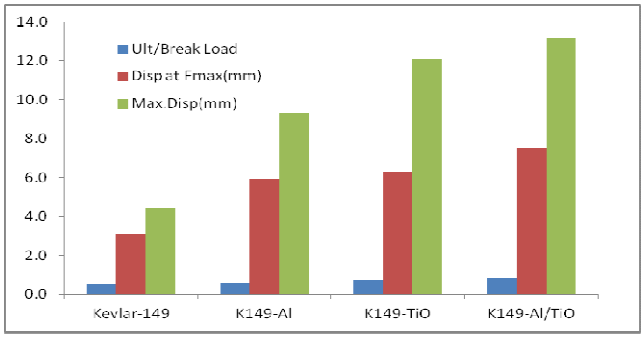

Figure 5: Graphical Plot for Specimen A/B/C/D (Compressive)

The figures 4 and 5 present the mechanical properties of the fiber when they are subjected to compressive load. The Specimen D is showing better performance than other specimen. The figures 6 and 7 show the validation of the results both experimentally and numerically. Abaqus CAE [19, 7, 8, 12, 14, 16, 22, 23] is used to generate the numeric magnitude of mechanical properties and the intensities are compared with each other for validation.

The figure 6 presents the comparative plot of experimental and numerical results. The curve of both experimental and FEA looks identical to each other, which shows the value of experimental is accurate [24, 25, 26].

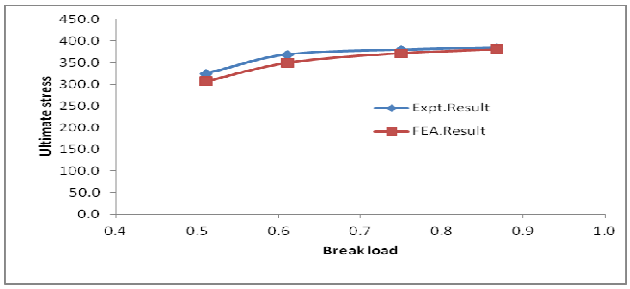

Figure 6: Validation of Results Plot (Tensile)

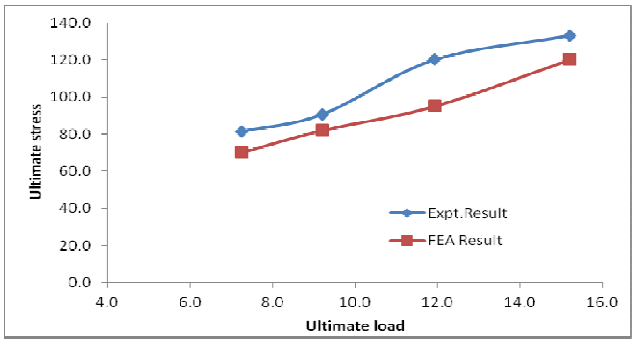

Figure 7: Validation of Results Plot (Compressive Load)

CONCLUSIONS

The Kevlar fiber is tested for mechanical properties under compression and tensile loading. We have tested four different types of configurations based on the percentage of nanocomposite on epoxy resin. From the results, it is evident that, the addition of nanocomposite on fiber increases the strength of fiber enormously. In addition, we also found that, specimen with one part titanium oxide and one part of aluminium oxide gives superior strength than compared two parts to titanium or two parts of aluminium oxide. Further, it is seen the dispersion of the epoxy and nanocomposite is very rich than other types of configurations.

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